

ANALYSIS OF IRIS SIGNATURE

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ANALYSIS OF IRIS SIGNATURE

Thesis submitted in partial fulfillment of the requirements for the degree of

Master of Technology

in

Signal and Image Processing

by

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under the guidance of

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June, 2015

dedicated to my parents...



National Institute of Technology Rourkela

CERTIFICATE

This is to certify that the work in the thesis entitled “**Analysis of Iris Signature**” submitted by *Amit Kumar Agrahari* is a record of an original research work carried out by him under my supervision and guidance in partial fulfillment of the requirements for the award of the degree of Master of Technology in Electrical Engineering (Signal and Image Processing), National Institute of Technology, Rourkela. Neither this thesis nor any part of it, to the best of my knowledge, has been submitted for any degree or academic award elsewhere.

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DECLARATION

I certify that

1. The work contained in the thesis is original and has been done by me under the supervision of my supervisor.
2. The work has not been submitted to any other Institute for any degree or diploma.
3. I have followed the guidelines provided by the Institute in writing the thesis.
4. Whenever I have used materials (data, theoretical analysis, and text) from other sources, I have given due credit to them by citing them in the text of the thesis and giving their details in the references.
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Amit Kumar Agrahari

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When I look back at my accomplishments in life, I can see a clear trace of my family's concerns and devotion everywhere. My dearest mother, whom I owe everything I have achieved and whatever I have become; my beloved father, who always believed in me and inspired me to dream big even at the toughest moments of my life; and sisters; who were always my silent support during all the hardships of this endeavor and beyond.

Amit Kumar Agrahari

Abstract

Iris recognition system gives automatic identification of an individual which depends upon iris pattern of the eye. Iris recognition system is most reliable, accurate and unique method for identification of individuals. Several other methods are also available for recognition, but iris system is broadly used because the iris pattern of each eye is unique in nature. John Daugman first used this method to identify successfully the identity of an individual. The objective of this work presented here is to obtain the iris template of an eye image and verify the template obtained from it. For performing this, CASIA database has used. For generating iris template of the eye, iris segmentation, normalization, feature extraction and matching are used. All these process are very important to obtain the iris signature. Initially, we have taken an image apply Hough transform to obtain iris circle parameters. Segmentation is used to obtain segmented iris image, and it will later locate boundaries of the iris, and then normalization is used which gives a rectangular dimensionless iris output. Finally for obtaining iris signature, 2D Gabor filter is used to extract the phase information from the iris. The Hamming distance is used for matching purpose. In this project, we used MATLAB framework for coding. Iris template is obtained by applying above methods which is in the binary and obtained from MATLAB. The system performs with 1180 image from CASIA database.

***Keywords:* iris, segmentation, normalization, feature extraction, Hamming distance, Gabor filter, template.**

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Chapter 1

THESIS OVERVIEW

THESIS OBJECTIVE

MOTIVATION

BACKGROUND AND SCOPE OF THE PROJECT

THESIS ORGANIZATION

Chapter 1

THESIS OVERVIEW

1.1 THESIS OBJECTIVE

The objective of this work is to generate an iris template in order to verify the iris signature of two individuals and to create a MATLAB GUI which demonstrate step by step the process of generating iris template from an eye image.

1.2 MOTIVATION BEHIND PROJECT

1. At the present time, identification of individuals is an adhesive issue. If a recognition system is not able to differentiate between two individuals, then there will be a chance of falsification occurs. In most of the technology fields, iris recognition is used for removing this error.
2. Our eye is among few organs of the body which is most stable. Iris pattern is unique for each individual in this world. Iris pattern starts forming from the time of 3 months of birth and continue developing till at the age of maturity. There are few other methods for recognition of individuals, but iris system is most accurate and stable in nature because of this nowadays in most of the sectors only iris recognition is used. The iris has a unique pattern it means that for each individual iris signature is different.
3. The main motivation behind this project is to obtain an iris pattern of different eyes so that identification between several iris images can be

performed. Nowadays security is also a very vast issue for fixing this iris systems is being used.

1.3 THESIS ORGANIZATION:

- **CHAPTER 1. INTRODUCTION:** This chapter focus on basic information of iris (pupil,limbus,etc).
- **CHAPTER 2. SEGMENTATION OF IRIS:** This chapter deals with the process of segmentation. Under this section lower and upper boundary of iris is been located.
- **CHAPTER 3. NORMALIZATION OF IRIS:** In this chapter after locating boundary of iris, normalization is performed. Eye image contains iris and limbus but for iris system only iris is useful so limbus part need to be removed from image because it doesn't contain any information.
- **CHAPTER 4. EXTRACTION OF IRIS INFORMATION:** This chapter provides the binary template of the iris image. Iris template is in binary form which can be represented in the form of an image.
- **CHAPTER 5. MATCHING OF IRIS TEMPLATE:** this chapter deals with identification between two individuals. When two iris template matches with each other then a person can be recognized.
- **CHAPTER 6. CONCLUSION AND FUTURE WORK:** This chapter deals with the scope and future work need to perform in the field of iris system technology.

Chapter 2

INTRODUCTION

IDENTIFICATION TECHNOLOGY

IRIS

RECOGNITION OF IRIS

ADVANTAGES OF IRIS SYSTEM

DISADVANTAGES OF IRIS SYSTEM

Chapter 2

INTRODUCTION

2.1 IDENTIFICATION TECHNOLOGY

For identify two individual iris recognition system is used. There are several types of technology present for the purpose of identification. Security and the validation of people are necessary for some different parts of our lives, with the vast majority needing to validate their personality consistently; samples incorporate ATMs, secure access to structures, and global travel.

1. DNA MATCHING: The distinguishing proof of an individual using the examination of body from DNA.
2. EAR: The recognizable proof of an individual utilizing the state of the ear.
3. Eyes - Iris Recognition: Visual Biometric it is used to distinguish between identification of two person with respect to their eyes iris pattern.
4. Eyes - Retina Recognition: The use of visual detection technology provides an example of retina in the back of the eye to achieve identification.
5. FACE RECOGNITION: Visual Biometric The examination of facial recognition or patterns for the validation or confirmation of a people character. The facial patterns vanishes after some age because the shape of the face will change.

6. **FINGERPRINT RECOGNITION: Visual Biometric** The usage of the edges and valleys (points of interest) in fingerprint method has been related to the pattern of fingers.
7. Biometric systems first captures the image then convert it into binary code with the help of some mathematical equations then it compares two person patterns and recognizes the individuals. Iris systems give more accurate and stable results because of this the recognition of people are easier and highly accurate.

2.2 IRIS

The iris is a meager, roundabout structure in the eye, in charge of controlling the width and size of the pupil and consequently the measure of light coming to the retina. The shading of the iris gives the color to the eye. In other terms, the pupil is the eye's opening and the iris is the stomach that serves as the gap stop. The iris is of brown color yet in few it is of blue and ruddy glow. Various shading of the iris depends on the measure of melanin present in it. Individual having blue iris has more amount of melanin in it. One eye with a white or somewhat blue, white iris is otherwise called a walleye. Iris lies in the middle of pupil and limbus of the eye. The iris comprises of two parts: the front pigmented fibrovascular known as a stroma and, underneath the stroma, pigmented epithelial cells. The iris is partitioned into two noteworthy parts:

1. The papillary zone is the internal area whose edge frames the limit of the pupil.
2. The limbus is rest whitish piece of eye remaining pupil.

Development of the iris starts from the third month of birth. The one of a kind example of the pattern formation of the iris is started during the first year of life, and after few years the complexity of pattern will increased. The main trademark that is reliant on hereditary qualities is the pigmentation of the iris, which decides its shading.

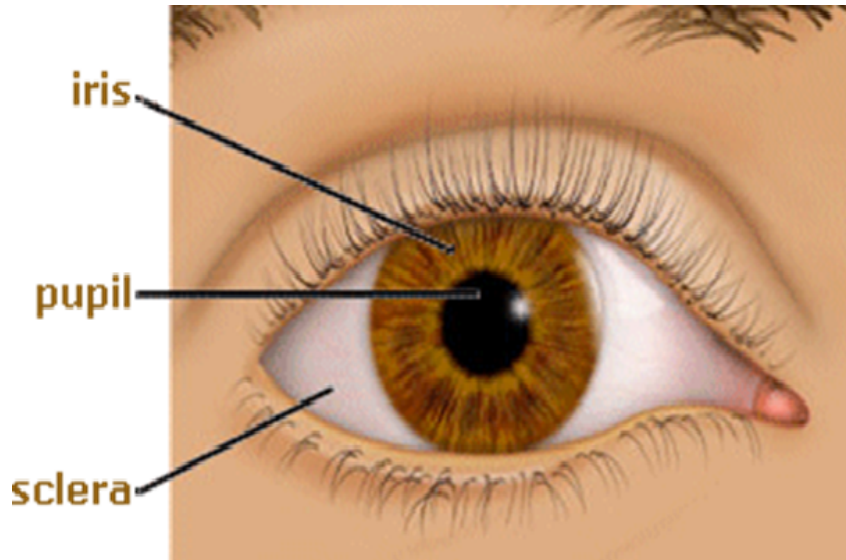


Figure 2.1: EYE IMAGE

2.3 RECOGNITION OF IRIS

The iris is a remotely unmistakable, yet ensured organ whose one of a kind epigenetic example stays stable for the duration of grown-up life because of this advantage it is extremely useful for recognizing people. When an image is captured for the purpose of obtaining iris code, then one must have the concept of image processing. The iris template obtained is presented in a binary code. This binary template consists of binary values that are obtained by extracting the information from iris. At the point when an eye image wishes to be distinguished by an iris system, using digital camera eye image needs to be capture, and after this iris code is generated. This code is then stored in a database that is used to store data for all eyes and named as reference code, for the purpose of identification this code must be matched to a present code of an individual. Iris recognition system is first performed successfully by Cambridge researcher, John Daugman in early nineties. Then after him lot of work has been approached in this field. John Daugman is the most recognized person in the field of iris recognition technology, researchers till these days follow his work. Other than Daugman there are several individuals has also done an

excellent work on iris recognition Wildes, Boles and Boashash, Lim et al. and Noh et al. [1] [8]. Contrasted and other biometric technologies, such as the face, recognition and fingerprint recognition, iris recognition can undoubtedly be considered as the solidest type of identification technology.

2.4 ADVANTAGES OF IRIS SYSTEM

1. **STABILITY:** Iris signature is most stable recognition system because iris patterns starts forming at the age of 3 months and remains same till the date of death.
2. **SECURITY:** Using iris system the problem of security and duplicity is solved because two iris pattern never matches. If any unwanted person is trying to access account of other person then he will be easily caught.
3. **UNIQUE PATTERN:** Iris systems have a template which is unique in nature because it is in binary format of fixed length. The code generated will never match with any other identification technique available.
4. **IDENTIFICATION TIME:** Generally in most of the technique available for identification takes up to 20 to 25 seconds to identify but in iris systems this time of response for matching is very less nearly 5 seconds. Because the output is in binary format which takes less time to execute and gives an accurate result.
5. **AGING EFFECT:** In fingerprint and facial recognition systems after some years the texture of finger and face has changed, but in iris system pattern does not change, thats why this is one of the most important advantages of iris systems.

2.5 DISADVANTAGES OF IRIS SYSTEM

1. For storing the code of iris system a lot of memory is required.
2. It is very expensive compared to other recognition techniques available.

Chapter 3

SEGMENTATION

SEGMENTATION OF IRIS

HOUGH TRANSFORM

CIRCULAR HOUGH TRANSFORM

DOUGMAN INTEGRO DIFFERENTIAL OPERATOR

LOCATING INNER BOUNDARY OF IRIS

LOCATING UPPER BOUNDARY OF IRIS

SEVERAL OTHER SEGMENTATION METHOD

IMPLEMENTATION

RESULTS AND CONCLUSION

Chapter 3

SEGMENTATION

3.1 SEGMENTATION OF IRIS

Segmentation of iris is used so that inner boundary and outer boundary can be found. The inner boundary is the lower limit of the pupil, and the outer boundary is the region from which whitish part of the eye starts or where pupil ends. Sometimes eyelashes come into the picture because of that some short of unwanted error occurs. The eyelids and eyelashes come between the upper and lower portion of the iris region. Reflection also affects the iris recognition. Segmentation is a method to find an iris portion of the image so that by applying some mathematical formulation lower and upper boundary can be detected. A method is obliged to isolate and prohibit these relics and finding the roundabout iris region. For the purpose of segmentation, several sub-parts are chosen circular Hough transform, Daugmans integro differential operator and active contour models [3]. The circular Hough transform is used to obtain the parameters of a circle that uses to find lower and outer boundary of the iris.

The segmentation is based on the nature of the image used. Images in the CASIA iris database don't contain specular reflections because the resolution of capturing machines is very high. Persons with obscurely pigmented irises will show small differentiation between the pupil and iris area if imaged under the normal light, it will create segmentation more difficult. The segmentation stage is a most important process for the accomplishment of an iris recognition

system since the information obtained from this will reduce the accuracy of the iris signature as a result the identification is not correctly verified.

3.2 LITERATURE REVIEW

3.2.1 HOUGH TRANSFORM

For calculating the unknown parameters of any given circle Hough transform, is used it may be radius, center, and circumference point coordinates. This method is mainly used in image processing to find parameters of given lines and circles. This transform is applicable for any shape or any geometry of articles. This method is based upon considering voting of maximum points which comes in the transformed image. Since it obliges that the sought highlights be determined in some parametric structure, the traditional Hough transform is most generally utilized for the location of general parameters, for example, lines, circles, ovals, and ellipses. A generalized Hough transform can be utilized in applications where a primary explanatory depiction of a highlight is unrealistic.

The most straightforward instance of Hough change is recognizing straight lines. By and large, the straight line $y = mx + c$ can be spoken to as a point (m, c) in the parameter space. Then again, vertical lines represent an issue. They would offer ascent to unbounded estimations of the slant parameter. M. Kawaguchi, Tsuyoshi, Mohamed Rizon, and Daisuke Hidaka [6] proposed Detection of eyes from human faces by Hough transform

$$r = x \cos \phi + y \sin \phi \quad (3.1)$$

where r is the shortest distance between two points on given line and ϕ is the slope of the line. It is in this way conceivable to connect with every line of the image to a point (R, ϕ) . Here, The plane is (R, ϕ) and it alluded to as Hough space for the arrangement of straight lines in two measurements. Hough transform in equation 3.1 transform (x, y) plane into (R, ϕ) plane.

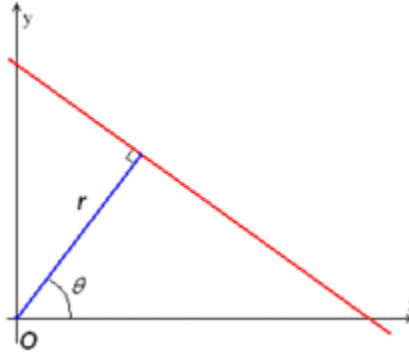


Figure 3.1: Graph for Eqn. 3.1

3.2.2 CIRCULAR HOUGH TRANSFORM

Circles are a typical geometric structure of enthusiasm for computer vision applications. The utilization of the Hough transform to locate circles will be clarified and illustrated. This is a specific illustration of the utilization of the Hough Transform to pursuit a parameter space.

The Hough change can be utilized to focus the parameters of a circle when various focuses that fall on the perimeter are known. A circle is described by its center points and radius

$$x = x_1 + r \cos \theta \quad (3.2)$$

$$y = y_1 + r \sin \theta \quad (3.3)$$

Here (x_1, y_1) are center coordinates and (r, θ) is radius and aperture angle of circle. When the angle rotates for 360 degree it gives perimeter of the circle.

When an edge image consists of several points on its edges, and some of the points are on these edges, then for finding the exact result of circle it needs to find only three points that are center coordinates and radius. Hough transform method consists of transformation of a line to a sinusoidal signal but here in iris system we are considering circular edges then it only transform from circle to another circle.

Here in iris recognize system circular Hough transform is used because the iris is circular in shape. While transforming a circle into Hough transform,

it provides us only a circle. Here an edge output of images is obtained, then for further finding radius and center coordinate of circular edge image circular transform is used. For determining the radius of a circle method of the maximum voting process, is chosen. Consider that for each edge point on the image a circle is formed by a fixed radius, and then at a point these points will intersect. The point where maximum number of intersection occur this point is to be considered as the center of the circle and using this radius will be obtained. A most extreme point in the Hough space will relate to the radius and center coordinates of the circle best characterized by the edge points.

The mathematical expression for circular Hough transform is given as

$$(x - a)^2 + (y - b)^2 = R^2 \quad (3.4)$$

Here (a, b) are center coordinates of the circle.

R is the radius of the circle.

The circular transformed equation is given as $(a - x)^2 + (b - y)^2 = R^2$. There are various issues with the Hough transform system such as in (m, c) space the vertical lines are not represented (it tends to infinity value). Also, the Hough change is computationally serious because of its simple methodology, and in this manner may not be suitable for continuous applications.

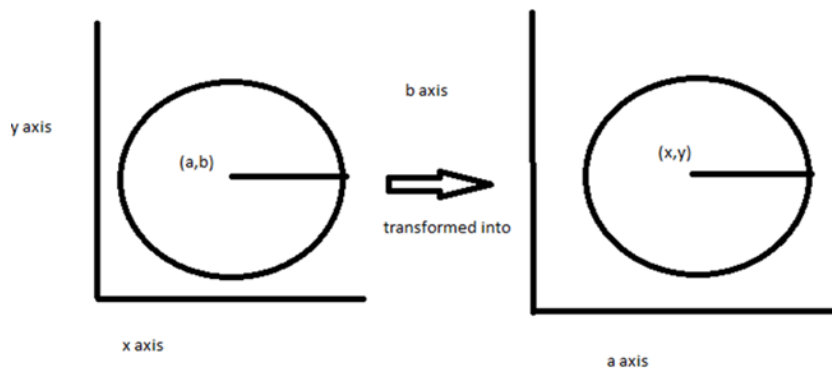


Figure 3.2: Hough transform of a circle

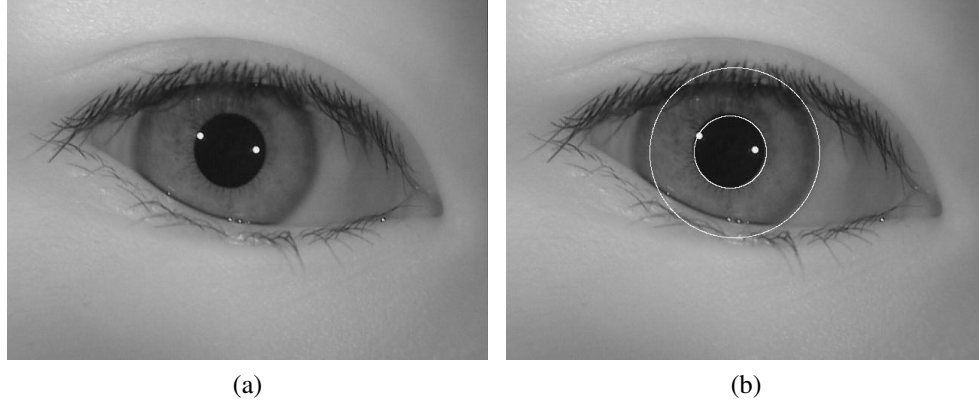


Figure 3.3: (a) an eye image (b) Hough transform of eye

3.3 DAUGMAN'S INTEGRO DIFFERENTIAL OPERATOR

For finding lower and upper boundary of the iris this operator is used. This method provides a way to obtain our main objective under this section. It locates the region between pupil and limbus part of the eye.

Daugmans intergro operator [2] is given as

$$\max_{(r,m_0,n_0)} \left| G_{\sigma}(r) \otimes \frac{\partial}{\partial r} \oint_{(r,m_0,n_0)} \frac{A(m,n)}{2\pi r} ds \right| \quad (3.5)$$

Where $A(m,n)$ is the eye image in m,n plane.

r is the radius.

$G_{\sigma}(r)$ is smoothing Gaussian function.

ds is the area over which integration occurs.

This complete equation provides a circular edges of iris image which will detect lower and upper boundary of the iris. The value of σ varies for smoothing the image because the Gaussian filter is changed with this parameter.

Each edge image must have some points on the circumference when taking these points into the consideration radius is obtained. Because iris has lots of circles in it then for each expanding circle when intensity is summed and find the rate of change of intensity for each expanding circle. The circle with a maximum rate of change occurs is considered as upper boundary, and a circle

has the lowest rate of change is considered as the lower boundary. For pupil, this change is maximum because of this pupil boundary is considered as the lower boundary. But practically this not always possible. Consequently, the in iris system pupil detection is one of the most important parts because pupil radius is considered as reference radius for iris detection. Daugman considered only 128 points of edge image for finding the upper and lower boundary of the iris. The system scans for the maximum rate of a change in intensity as a range of the radius increases. For each next circle or expanding circle, the rate of change must be increased.

When Hough transformed is applied to the iris circle radius is obtained then for applying integro operator the iris must be obtained in circular edge form. Integro operator does not need any threshold to applied this works only on a differential process. In few cases, eyelids and eyelashes will occur in iris image then there will exist some problem for removing this eyelid removal method is been used.

3.3.1 LOCATING INNER BOUNDARY OF IRIS

The limit of the pupil is a circular edge. The pupil is black in colour while the iris is lighter than pupil with changed pigmentation. It identifies the pupillary boundary as when the rate of change of integral operator is minimum for expanding circles of the iris.

$$\max_{(r,m_0,n_0)} \left| \frac{\partial}{\partial r} \oint_{(r,m_0,n_0)} A(m,n) ds \right| \quad (3.6)$$

The partial derivative used here because the image needs to be smoothed for noise purpose. Here $A(m,n)$ is image of eye, ds is differential operator. R is the radius and (m,n) is the coordinates. For every extending circles and for every estimation of its radius the total image power is summed more than a settled number of focuses lying on every circle [3].

3.3.2 LOCATING UPPER BOUNDARY OF IRIS

Once the center and lower boundary of the iris is detected then next step is to find upper boundary which is between iris and limbus. In some cases pupil is not very focused in iris these are the some consideration assumed. The radial separations to one side and other side of limbus may change by as much as 20%, and thus both separations must be considered keeping in mind that the end goal is to produce a suitable iris boundary. In eyes the region between iris and limbus upper boundary is not been used so this part is always taken as redundant data for image this must be eliminated.

The same technique is used for finding iris lower boundary is applied to find the upper boundary (expanding circles concept). But in this method alteration is being used. For most of the cases, the distance between upper and lower eyelids is not equal, if two bands are provided one is at 0 degrees and another is at 180 degree considering the pupil axis a reference axis. Then it needs to provide 45 degree angle to both the sections. The distance between upper side and lower side of iris is calculated one by one. In some cases the iris is also not separated in center of the eyes for removing this issue shifting is been provided to the image so that the iris obtained is in center of the eye. Due to this the expanding circle concept is not been used here so these are replaced by expanding pie wedges. As in previous case maximum rate of change in intensity is considered for finding upper boundary after compensating left and right side of iris differential operator is been applied to obtain upper boundary.

Mathematically this operation is performed as equations which is used by Dougman [3].

$$\max(r_0)[1.5r_0, 10r_0] \frac{\partial}{\partial r} \int_{\rho=r-\delta}^{r+\delta} \frac{2}{\pi \delta r} \int_{\theta=\phi-\frac{\pi}{8}}^{\phi+\frac{\pi}{8}} A(\rho, \theta) \rho d\rho d\theta \quad (3.7)$$

where r_0 is the radius of the pupil, δ is flimsy spiral zone (commonly $0.1 r_0$), $A(\rho, \theta)$ is iris image, further step is regarding polar directions ρ and θ . Fur-

thermore ϕ equals to 0 to 180 degree comparing to either the 0 degree and 180 degree of the upper and lower separation of the iris.

For finding area of the pupil and limbus, the center point of the pupil is considered as origin. The dimensionless iris is used here to obtain the maximum rate of change because there are different iris pattern are generated for individuals to outcome from this, the dimensionless coordinate is being used. The general size and shape of the iris images are not same sometimes this will vary depending upon the structure of the eyes.

3.4 SEVERAL OTHER SEGMENTATION METHODS

Different researchers use systems like the segmentation methods. The iris confinement proposed by Tisse et al. [10] is a blend of the Integro-differential and the Hough change. The Hough change is calculated to find the pupil radius and after that the Integro-differential is utilized to precisely find pupil and limbus utilizing a littler pursuit space. Lim et al. limit pupil and limbus by giving an edge guide of the force estimations of the image. The center point of pupil is then picked utilizing a division system that passes opposite lines from each two focuses on the edge map. The middle point is then acquired by voting the point that has the biggest number of line intersects. The pupil and limbus limits are then chosen by expanding the span of a virtual circle with the chose focus point and picking the two radii that have the greatest number of edge crosses by the virtual hover as the pupil and limbus radii [8].

3.5 IMPLEMENTATION

Here circular Hough transformation method is used to find lower and upper boundary of irises. Firstly canny edge operation is applied to find edge image then gradient in horizontal and vertical direction is evaluated using this magnitude and direction of the points will be calculated, as recommended by Wildes et al. [10]. For finding pupil exact separation vertical and horizontal, both directions needs to be considered. An adjusted rendition of Canny edge iden-

tification MATLAB capacity [7] was actualized, which took into consideration for finding the magnitude of the gradient.

The radius range may vary for different databases, but one can also choose it manually according to its database. For CASIA database, the range of radius is from 90 to 150 pixels, and pupil radius range lies between 25 to 75 pixels.

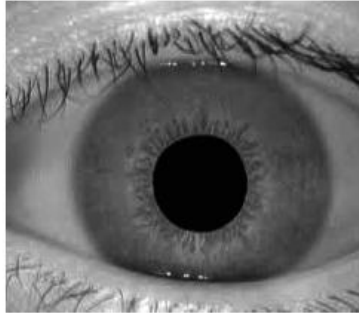
For segmentation process after capturing eye image needs to be of high resolution and high quality. The first procedure is to apply Hough transform to locate the center of the eye then find the radius of the circle using Daugmans method. The pupil must be separated with a high degree of accuracy otherwise it causes some problem to detect boundary. Apply Daugman differential integro operator to find inner and outer boundary of the iris region regardless of any eye. Iris of the eye must be circular in nature. By applying Canny edge operator, edge image is obtained then by applying derivative process to the intensity value of the image the boundary of the iris is obtained. After this process, we have a radius, center coordinates for both the upper and lower boundary circles that are we have six parameters. As this is already known to us that the pupil is always lie within the iris, so it is also circular. Pupil is 0.1 times of iris radius. After finding these two circles segmentation part, is been completed then go to normalization section of iris recognition.

3.6 RESULTS AND CONCLUSION

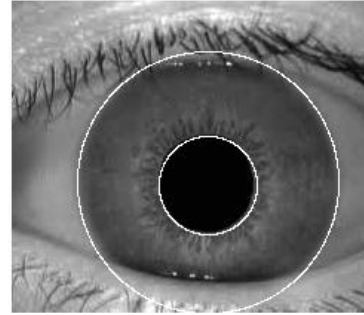
The CASIA database gave an excellent result for segmentation since eye images used in the database are of high contrast and highly invasive in nature. 1580 images has been tested under CASIA database in which only approx 70% of the images are giving the correct result for boundaries. Several of them are not properly showing the boundary of the iris.

The eyelid identification system additionally demonstrated very successful and figured out how to segregate most blocking eyelid areas. One issue was that it would infrequently disengage a lot of the iris region, resulting less precise value for output. Because there are less amount of images present in it

that is why there is some problem of eyelashes and eyelids occurs. For eyelids and eyelashes, the CASIA database is giving the very high result. For CASIA database images, iris segmentation is completed instead of the effect of eyelashes and eyelid occlusion.

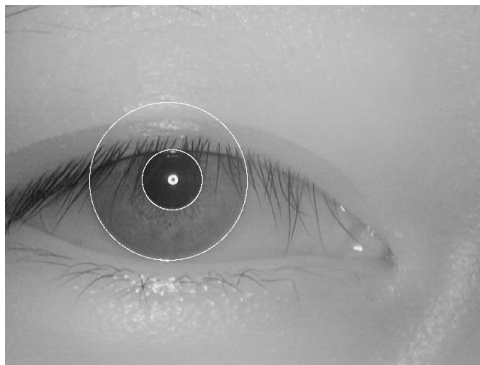


(a)

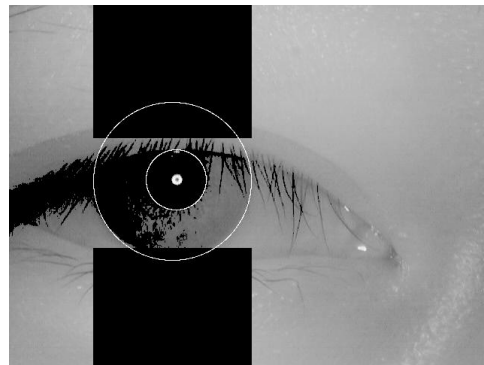


(b)

Figure 3.4: (a) an eye image (b) Segmented image



(a)



(b)

Figure 3.5: (a) an eye image (b) Segmented image

Output of CASIA database images that are properly segmented

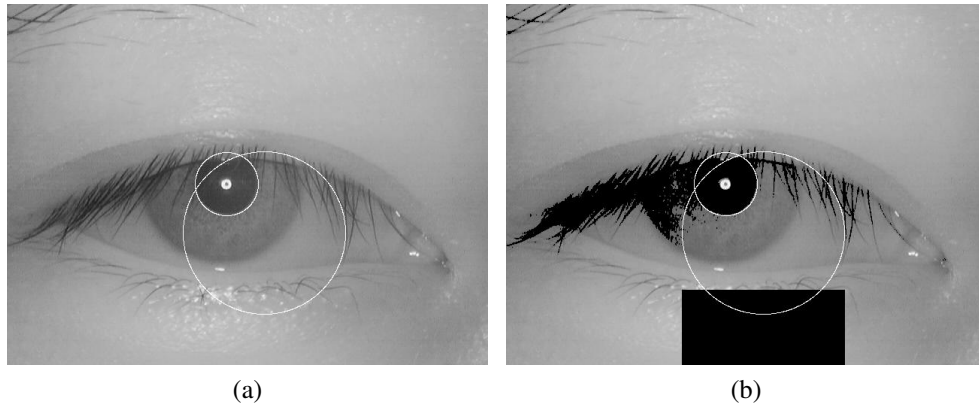


Figure 3.6: (a) eye image (b) segmented image

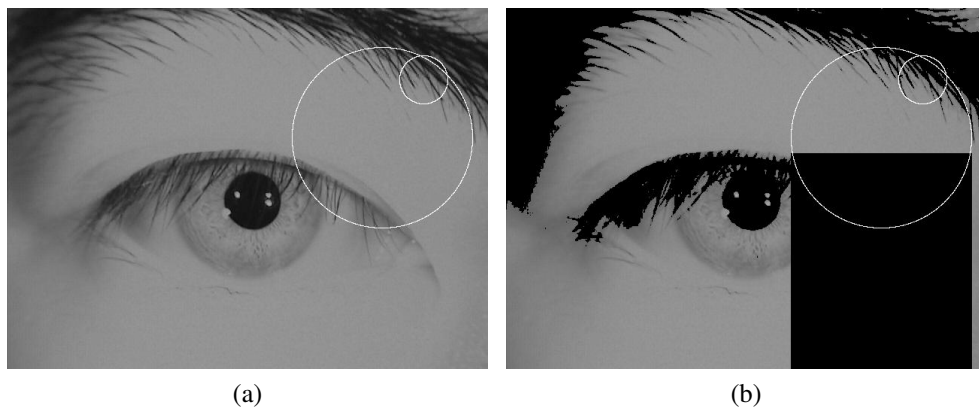


Figure 3.7: (a) eye image (b) segmented image

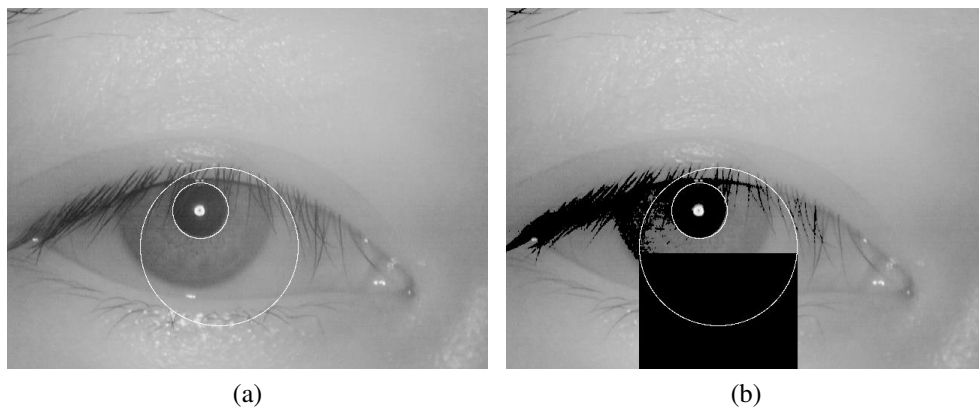


Figure 3.8: (a) an eye image (b) Segmented image
Output of CASIA database images that are not properly segmented.

Chapter 4

NORMALIZATION

OVERVIEW

DAUGMANS TRANSFORMATION (RUBBER SHEET MODEL)

VIRTUAL CIRCLES

WILDE'S IMAGE REGISTRATION METHOD

OTHER NORMALIZATION METHODS

NONLINEAR NORMALIZATION METHODS

RESULTS

CONCLUSION

Chapter 4

NORMALIZATION

4.1 OVERVIEW

Normalization in image processing plays a very important role. In image processing, it is related with the pixel intensity or contrast values of an image. Applications incorporate photos with poor complexity because of glare. Sometimes the illumination or intensity of pixels is very low due to that the image is not clear. In iris recognition systems it is used to convert polar coordinate system to one normalized form (the shape and size of iris in many eyes are not same it varies with person to person some of the eyes do not have circular) to overcome from this normalization of iris image is performed so that the representation is same in every captured image with same dimension. If the dimension of two iris are not same (shape of pupil is not circular) then normalization process is not provide correct result, resulting the feature extraction and matching does show blurred template. When the level of intensity is changed then the dimensional irregularity occurs in the iris images. Sometimes the brightness or intensity of the pixels is very low due to that the image is not clear to the viewer.

The normalization results in the same dimension of two irises so that the photo of two irises with different shape gives correct output to obtain feature extraction. Daugman's rubber sheet model is used here to normalize segmented iris image to extract information [2].

4.2 LITERATURE REVIEW

4.2.1 DAUGMANS TRANSFORMATION (RUBBER SHEET MODEL)

Daugmans rubber sheet model is used to transform segmented iris image to normalized image. It transforms Cartesian coordinate into polar coordinate regardless of shape and size. Considering a segmented iris image whose Cartesian coordinates is given by $A(x,y)$. This $A(x,y)$ image is transformed into $A(r, \theta)$ where r varies between 0 to 1 and θ angle between 0 to 360 degree. The remapping of $A(x,y)$ into dimensionless polar coordinate is illustrated below as

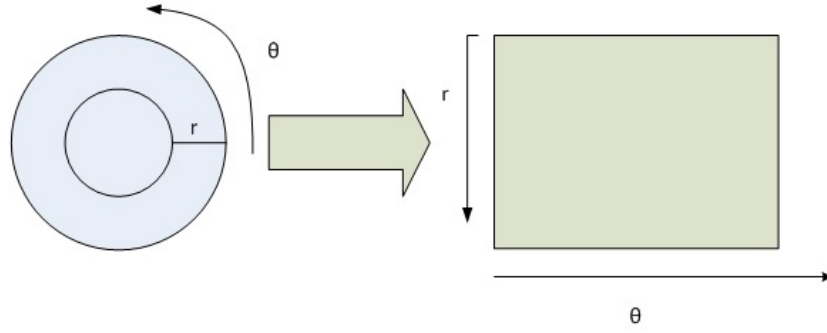


Figure 4.1: Rubber sheet model

$$A(m(r, \phi), n(r, \phi)) \rightarrow A(r, \phi) \quad (4.1)$$

$$m(r, \phi) = (1 - r)m_p(\phi) + rn_l(\phi) \quad (4.2)$$

$$n(r, \phi) = (1 - r)n_p(\phi) + rn_l(\phi) \quad (4.3)$$

where,

m_p and n_p is coordinates of upper boundary of pupil.

m_l and n_l is coordinates of lower boundary of pupil.

$(m(r, \theta))$ and $(n(r, \theta))$ are Cartesian coordinates of points on pupillary boundary.

$$m_p(r, \phi) = m_{po}(\theta) + r_p \cos \phi \quad (4.4)$$

$$n_p(r, \phi) = n_{po}(\theta) + r_p \sin \phi \quad (4.5)$$

$$m_l(r, \phi) = m_{lo}(\theta) + r_l \cos \phi \quad (4.6)$$

$$n_l(r, \phi) = n_{lo}(\theta) + r_l \sin \phi \quad (4.7)$$

where m_{po} and n_{po} is coordinates of lower boundary of pupil.

This model transforms each and every point on iris boundary into a polar coordinate (r, ϕ) .

The rubber sheet model considers pupil enlargement and irregularities in sizes to obtain standardized representation for unchanging dimension. As a result of this pupil is considered as center of the iris. Despite the fact that the homogeneous rubber sheet model validates for pupil expansion, imaging separation, it doesn't provide rotational irregularities. In Daugman recognition system, orientation is represented at the time of matching by changing the position of iris templates in the direction of ϕ unless two iris signatures matched [2].

MATHEMATICAL EXPLANATION OF TRANSFORMATION

Let us consider an equation

$$m(r, \phi) = r + \phi \quad (4.8)$$

$$n(r, \phi) = r^2 + \phi^2 \quad (4.9)$$

if we perform a mathematical operation like addition which is resulting another equation as

$$A = m(r, \phi) + n(r, \phi) \quad (4.10)$$

this A must have a function of (r, ϕ) .

Which is a function of (r, ϕ) .

So $m(r, \phi)$ and $n(r, \phi)$ is transformed into $A(r, \phi)$.

Here r and ϕ is assumed just for illustrating an example.

4.2.2 VIRTUAL CIRCLES

In the Boles [1] paper, the diameter of the iris images considered with constant diameter. When considering two images first one is taken as the reference image and another one as a test image. Work done by Boles is mainly related to normalization since for matching of two iris templates this must be performed for finding hamming distances. Once the iris region considered as same shape and dimension, then there will be some chances that intensity value is not used. A normalization threshold needs to be chosen so that the quantity of information obtained from iris same for other irises too. Daugman's homogeneous model resembles with this model. However scaling is related with match time and plays a significant role in iris region for finding a template.

4.2.3 WILDES IMAGE REGISTRATION METHOD

In this technique, an acquired image, $A(a, b)$ would be adjusted to an image in the database $A(a, b)$, then the correlation is performed. It chooses a mapping function which is used for the purpose of shifting as shown by equation below

$$\iint (A(a, b) - B(a - x, b - y))^2 da db \quad (4.11)$$

This is called alignment process and is used for rotation and scaling. The mapping function is related and similar to function of transformation of image coordinates (a, b) to (a', b')

$$\begin{pmatrix} a' \\ b' \end{pmatrix} = \begin{pmatrix} a \\ b \end{pmatrix} - sR(\phi) \begin{pmatrix} a \\ b \end{pmatrix} \quad (4.12)$$

Where s is scaling factor and $R(\phi)$ is matrix rotation constant. This is based on iterative method. Wildes normalization procedure is taking into account a different methodology contrasted with Daugman's technique. Contrasting with Daugman's methodology, the normalization technique would be tedious in identification application [12].

4.3 OTHER NORMALIZATION METHODS

Lim et al. [8] utilizes a strategy very much alike to the pseudo polar change of Daugman. In this strategy, finding the center of pupil and the lower and upper boundary of iris, the composition is changed into polar directions depending upon angle.

Boles [1] Normalization strategy is additionally like Daugman's system with the distinction that it is performed at the time of matching. The system is taking into account the diameter across of the two coordinating irises. The proportion of the diameter across iris are computed and the measurement of irises are acclimated to have the same measurements. The quantity of tests is additionally altered and it is situated to a force of-two whole number keeping in mind the end goal to be suitable for the dyadic wavelet change.

Also, there has been some examination on the pseudo polar change with a specific end goal to improve its execution. The work displayed by Joung et al. [5] examines the different conceivable outcomes of iris change. The researchers concentrates on the way that pupil and limbus are not generally concentric and presents a strategy to enhance the unwrapping procedure.

4.4 NONLINEAR NORMALIZATION METHODS

The unwrapping system proposed by Daugman expect that iris examples are linearly dispersed in the radial direction, which permits the mapping strategy into the interval of $[0\ 1]$. The image acquisition procedure changes the pupil size to a legitimate range by adjusting the brightness of the image. The feature extraction procedure is by mainly connected to numerous different points of the iris surface, which would remunerate the nearby nonlinear varieties. The non-linear normalization algorithm proposed by Yuan and Shi [13], considers a nonlinear behavior of iris patterns because of change of pupil size. So as to unwrap an iris area legitimately, a non-direct model and a normalization model are used.

This method consists of three assumptions

1. The inner and outer boundary must have concentric circles.
2. If angle θ of pupil changes from 0 to 360 degree then the separation between inner and outer boundary must have constant value.
3. The size of pupil remains same while rotation occurs.

4.5 RESULTS

In this work CASIA database is used for obtaining iris template. These are few iris normalized images obtained after applying normalization process.



Figure 4.2: Normalized image of iris



Figure 4.3: Normalized image of iris



Figure 4.4: Normalized image of iris

Figure 4.2,4.3 and 4.4 showing normalized output of several images



Figure 4.5: Normalized image of iris



Figure 4.6: Normalized image of iris



Figure 4.7: Normalized image of iris

Figure 4.5, 4.6 and 4.7 showing normalized output of several images after applying Gaussian filtering.

In these obtained results large semicircle is showing the normalized part of iris section and small circle showing the normalized part of papillary section. In CASIA database some of the normalized images are not very clear so that for the purpose of visibility these obtained images are worthless but when we apply extraction process it will generate iris template.



Figure 4.8: Normalized image of iris



Figure 4.9: Normalized image of iris

Figure 4.8 and 4.9 shows less visibility of iris and pupil pattern obtained.



Figure 4.10: Normalized image of iris



Figure 4.11: Normalized image of iris

Figure 4.10 and 4.11 is obtained after applying Gaussian filtering

4.6 CONCLUSION

The iris normalized images obtained from CASIA database. These acquired images are highly effective in the further process of feature extraction. CASIA database has 1180 images and there are only 50% obtained normalized images have iris and pupil sections are visible, but this will not effect on our result because we need to extract information from these normalized images.

Chapter 5

EXTRACTION OF IRIS INFORMATION

OVERVIEW

GABOR FILTERING

LOG GABOR FILTER

IMPLEMENTATION OF FEATURE EXTRACTION

RESULTS AND CONCLUSION

Chapter 5

EXTRACTION OF IRIS INFORMATION

5.1 OVERVIEW

After segmentation and normalization, iris recognition needs to obtain iris template for which process of feature extraction is used. Feature Extraction means to produce information from the source and use it for get the output. In iris systems, feature extraction is used to collect information that consists of iris region. This information gives us a fixed and stable binary output using which iris template has been generated. In iris region only significant regions must be extracted from information because other regions do not have more accurate information.

The iris template that is generated after feature extraction is in matrix form whose elements are in binary form either 0 or 1. This matrix also needs a matching matrix for the purpose of matching using that identification of individuals is achieved. For extraction purpose, the normalized image must be convolved with a 2-D Gabor filter.

5.2 LITERATURE REVIEW

5.2.1 GABOR FILTERING

For extracting the information from iris normalized image Gabor filter is used. This information is in textural form so it needs to be converted into binary form, for this convolution property is used. Here 2 D Gabor filtering operation is used. A Gabor filter is formed by convolving a sine or cosine wave with a Gaussian filter.

The mathematical expression for 2D Gabor filter is given as

$$X(r, \phi) = \exp(-2\pi i \omega (\phi - \phi_0)) \exp\left(\frac{-(r - r_0)^2}{a^2}\right) \exp\left(\frac{-(\phi - \phi_0)^2}{b^2}\right) \quad (5.1)$$

Where r is the radius

ϕ is the angular distance

ω is the frequency in Hertz a, b are constants

Gabor filter is a complex filter which provides a real and an imaginary output. In iris recognition systems when feature extraction process is accomplishing real and imaginary part both is considered. Daugman uses 2D Gabor filter for extraction of information from iris image and to encode the output in binary format [3].

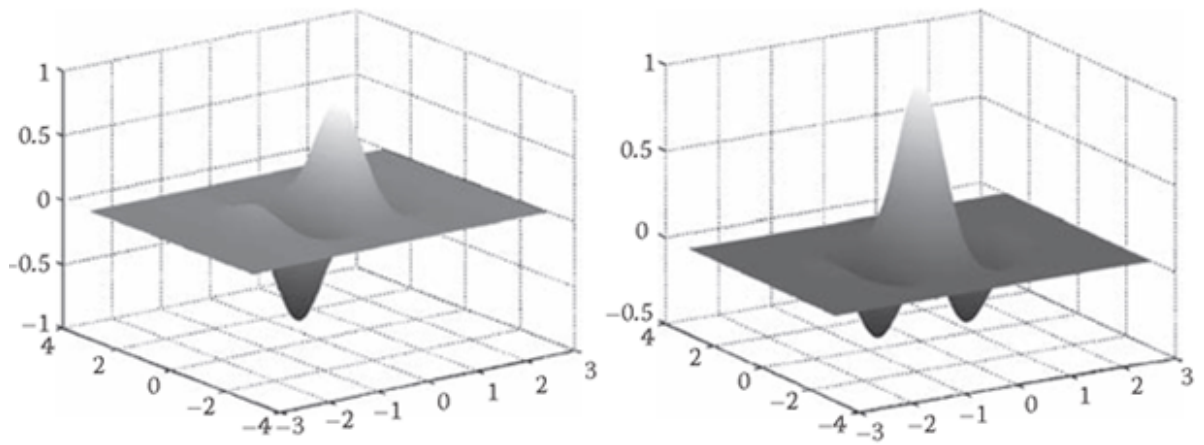


Figure 5.1: Real and imaginary part of 2D Gabor filter.

For obtaining binary output iris image is convolved with 2D Gabor filter. As known convolution is a shifting property so the size of image must be same with the size of filter for this Gabor filter is divide into 1D filter. When image is convolved with filter then for each real and imaginary part two output values will come either 0 or 1. The mathematical expression for this process is given below as

$$MSB(r, \phi) = 1 \text{ if } \operatorname{Re} \oint e^{-2\pi i \omega(\phi - \theta)} e^{\left(\frac{-(r-\rho)^2}{a^2}\right)} e^{\left(\frac{-(\phi-\theta)^2}{b^2}\right)} A(\rho, \theta) \rho d\rho d\theta > 0 \quad (5.2)$$

$$MSB(r, \phi) = 0 \text{ if } \operatorname{Re} \oint e^{-2\pi i \omega(\phi - \theta)} e^{\left(\frac{-(r-\rho)^2}{a^2}\right)} e^{\left(\frac{-(\phi-\theta)^2}{b^2}\right)} A(\rho, \theta) \rho d\rho d\theta \leq 0 \quad (5.3)$$

$$LSB(r, \phi) = 1 \text{ if } \operatorname{Im} \oint e^{-2\pi i \omega(\phi - \theta)} e^{\left(\frac{-(r-\rho)^2}{a^2}\right)} e^{\left(\frac{-(\phi-\theta)^2}{b^2}\right)} A(\rho, \theta) \rho d\rho d\theta > 0 \quad (5.4)$$

$$LSB(r, \phi) = 0 \text{ if } \operatorname{Im} \oint e^{-2\pi i \omega(\phi - \theta)} e^{\left(\frac{-(r-\rho)^2}{a^2}\right)} e^{\left(\frac{-(\phi-\theta)^2}{b^2}\right)} A(\rho, \theta) \rho d\rho d\theta \leq 0 \quad (5.5)$$

Here (r, ϕ) is radius and angle of iris.

ω is the natural frequency which depends upon the value of constant a and b .

θ is the angle for selected zone of analysis.

Each part of Gabor convolved image is giving two values which correspond with real and imaginary part. Real and imaginary part both give two values, according to given conditions. The MSB of iris template is obtained from the real part that is shown in equation no. 5.2 and 5.3. The LSB of iris template is derived from the real part that is shown in equation no. 5.4 and 5.5.

As already known that for any image phase gives more information rather than its magnitude so here in iris system we focus on phase information regardless of magnitude information. Considering just the phase information, it will provide encoding of segregating data in the iris while removing the redundant data, for example, illumination, which is given by amplitude. For this phase quantization concept is used here.

5.2.2 LOG GABOR FILTER

Log Gabor filter is used in Gabor filter because it gives better statistical results for images. Gabor filter is used to obtain both real and imaginary part of any signal and Fourier transform gives frequency component. So that we cannot find a particular frequency for this purpose log Gabor filter is used. Mathematical expression is given as

$$X(f) = \exp \left\{ \frac{-\left(\log \frac{f}{f_0}\right)^2}{2\left(\log \left(\frac{m}{f_0}\right)\right)^2} \right\} \quad (5.6)$$

Here f, f_0 and m are the filter parameters depending upon frequency. The ratio of m/f_0 must be constant. Using these filters the frequency range is altered with respect of log that's why this range of frequency is reduced and the natural image provides a better result. The main disadvantage of log Gabor filter is it will not provide result at zero frequency.

5.3 IMPLEMENTATION OF FEATURE EXTRACTION

When normalized iris image output is convolved with 2D Gabor filter it will generate an output in the form of a matrix whose elements are either 0 or 1. For this process, 2D Gabor filter is split into 1D Gabor form and then this is convolved with 1D normalized image. The rows of the 1D pattern are considered as 1D signal each row corresponds to a circular value in iris pattern. Because we are using here the concept of polarization, so the output obtained after filtering is phase quantized to get the binary template. The output of phase quantization is in a gray format so that only one-bit change occurs.

5.4 RESULTS AND CONCLUSION

The iris template obtained after feature extraction is in binary form matrix. Here that matrix is converted into an image so that the output will be shown.

The template obtained has the dimension of 20*480 pixels.



Figure 5.2: Iris template

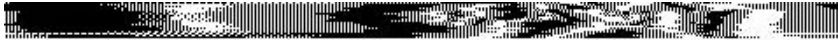


Figure 5.3: Iris template



Figure 5.4: Iris template

Figure 5.2,5.3 and 5.4 are showing iris template of different images obtained after process of feature extraction. Some of the elements of these three templates are zeros and others are ones.

Chapter 6

MATCHING OF IRIS TEMPLATE

OVERVIEW

HAMMING DISTANCE METHOD

IMPLEMENTATION

RESULTS AND CONCLUSION

Chapter 6

MATCHING OF IRIS TEMPLATE

6.1 OVERVIEW

Matching is used to compare the result obtained by iris templates. If matching is not successfully performed, then the iris recognition system does not identify the actual identity of the individual. Matching between two iris templates uses XOR binary operation. Daugman utilizes XOR operation for matching a however couple of different researchers utilizes another system for acquiring feature extraction and then perceive the process of matching. If matching is completed successfully, then the next step is to identify the individual iris signature with the database if the present obtained signature matches with database signature then identification is complete else it will show the false result. In this thesis method of Hamming distance is used[3].

6.2 HAMMING DISTANCE METHOD

The basic concept of hamming distance depends upon matching of two symbols in any two given unknown string. If two equations have the same variable in it, then the Hamming distance between them is zero, but if any of the variables changed then hamming distance is changed. Let us consider an example if one string is A= abcdefgh and another string is B= abcdefgh then the Hamming distance between string A and string B is 0. If any of the alphabets changed then hamming distance obtained is not 0 it gives some value. In iris systems,

the template obtained is in binary form.

Considering two binary strings if string A= 01100011 and string B= 11001010 then the Hamming distance between these two strings are 1. The mathematical expression for obtaining hamming distance which is used in image processing is given as

$$HD = \frac{1}{M} \sum_{k=1}^M A_k(XOR)B_k \quad (6.1)$$

Where, M is the total number of bits in string.

A and B is the binary string to be compared.

If two strings are totally different then the hamming distance is equals to 0.5. This happens because one part of the bits are matched and other part does not match. If two iris templates are same then the hamming distance between them are 0 [3].

6.3 IMPLEMENTATION

In this work when two generated iris templates are matched with each other, this will provide a better result. The XOR operation is performed between iris templates to obtain the Hamming distance. These rows and columns have binary values, i.e. either 1 or 0. The iris template, obtained is in matrix form of 480*20. It means the template has 20 rows and 480 columns. These rows and columns have binary values, i.e. either 1 or 0.

6.4 RESULTS AND CONCLUSION

The Hamming distance obtained after matching is 0 for matched templates and 1 for unmatched templates. But because of noise occurred the matching will never gives 100 percent accurate matching. CASIA database is used here, so the segmented images obtained are not giving very satisfactory result (eyelashes and eyelids are occurring because of that iris boundary is not clear). Figure 6.1 is showing the iris template between two different images it has some high intensity points and some low which means matching fails. Fig 6.2



Figure 6.1: Template of two different irises



Figure 6.2: Template of two same irises

showing the iris template of same image.

Chapter 7

RESULTS, CONCLUSION AND FUTURE WORK

RESULTS

CONCLUSION AND FUTURE WORK

Chapter 7

RESULTS, CONCLUSION AND FUTURE WORK

7.1 RESULTS

In this work iris recognition of CASIA database and other images has been verified. There are several steps used to obtain iris template. Resulting binary bits of the template is stored in a 20*480 matrix. The first step performed here is to locate upper and lower boundary of the iris image. The second step is to obtain a segmented image. The third step is to get a normalized image. And the final step is to extract the information consists of the iris. The result of iris recognition to get iris template is shown below step by step.

figure 7.1, 7.2, 7.3 and 7.4 are showing how iris signature obtained step by step.

7.2 CONCLUSION AND FUTURE WORK

In this project, the iris template obtained is in matrix form whose elements are in binary format. The dimension of the matrix is 20*480 which means the iris template obtained for each iris image consists of 9600 bits or 1200 byte data. Here CASIA database is being used, so the template obtained for each image is giving values in the binary form. For a few of the images, all the elements

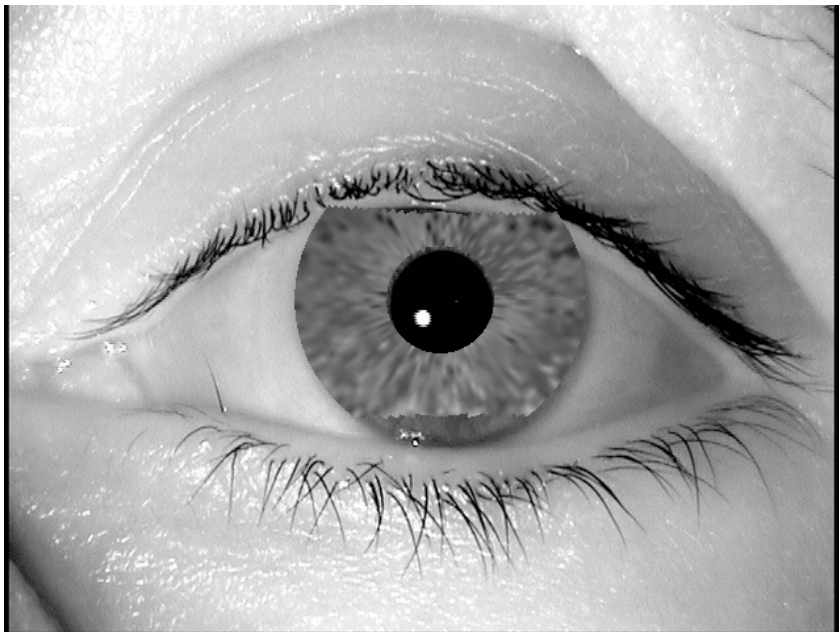


Figure 7.1: Eye image

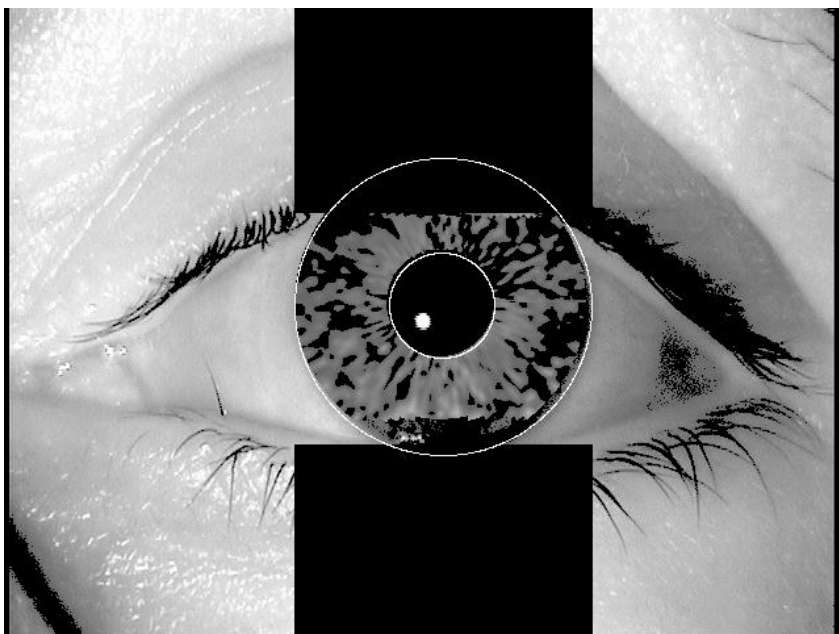


Figure 7.2: Segmented image



Figure 7.3: Normalized image

of the matrix are coming zeros that are a disadvantage because the process of normalization and detection of upper and lower boundary is not accurately



Figure 7.4: Iris template

achieved.

For the prospectus of future work iris signature

1. There are a lot of security issues occurring these days for removing all of these iris signature needs to be highly accurate for identification because in some cases due to reflection, and other effects identification fails.
2. With the help of iris recognition system identification is highly achieved, but consider if after more than 50 to 60 years, the iris pattern of eye will change, then identification is not possible, so it needs to be verified whether after some age iris pattern changes or not.
3. Removal of reflection and other issues are also a problem in the iris.

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